Data describing Semibalanus balanoides embryo development in a laboratory (EUROWINTER2 project)

Website: https://www.bco-dmo.org/dataset/636941
Data Type: experimental
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Project
» Climate Change and Biogeography: Effects of Extreme Events (EUROWINTER2)

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Dataset Description

This dataset contains results of a laboratory experiment on *Semibalanus balanoides* embryo development under varying air and water temperatures.

Methods & Sampling

Adult acorn barnacles, *Semibalanus balanoides,* were collected from the beach at the end of Park Rd, Woods Hole, Massachusetts, USA (41.532° N, 70.671° W) on December 6, 2012. Individuals were collected on cobbles and transported to the University of South Carolina at Columbia where they were placed within environmental chambers.

Treatment containers were placed within environmental chambers (0.6 m3 interior volume) with individual temperature and lighting controls. Barnacles were exposed to a simulated semi-diurnal tide cycle with the timing of both the tide and daylight schedule at Woods Hole. Seawater was pumped from the experimental chamber to a head tank and the barnacles were exposed to the air for 6 h to simulate low tide and then submerged for 6 h to simulate high tide. Seawater was constantly aerated. Every two weeks the timing of the tide and light cycle was adjusted to match that of Woods Hole. Treatment containers were covered with transparent Plexiglas to prevent evaporation but allowed the barnacles to be exposed to the light cycle. Barnacles were liberally fed every 2 days throughout the experiment by addition of Spat Formula (Innovative Aquaculture Products LTD), a commercial aquaculture product containing the *diatoms Chaetoceros-B* and *Phaeodactylum tricornutum* and the flagellate *Nannochloropsis oculata*, at a final concentration of 108 cells L−1. The seawater in the experimental chambers was maintained at 35 ppt and was replaced every two weeks. Feces and settled algal particles were removed weekly. The water changes occurred during low tide (when the water was in the head tank), allowing it to equilibrate to the treatment temperature before the animals were

submerged.

In three of the treatments, barnacles were exposed to the same air and water temperature of 7°, 10°, and 13 °C to represent a range of environmentally relevant temperatures spanning the temperature threshold proposed in the literature (Barnes, 1963; Crisp, 1959; Crisp and Patel, 1969). The temperatures were maintained using the internal temperature controls of the incubators and monitored, which indicated that the mean temperature of each treatment over the duration of the experiment was within 0.5 °C of the intended temperature. Two additional, mixed-temperature treatments were also conducted, one with 7 °C air temperature and 13 °C water temperature, the other with 13 °C air temperature and 7 °C water temperature. These treatments were used to differentiate among the effects of air temperature, water temperature, and mean temperature on reproduction.

All experimental treatments were conducted simultaneously over a total of 63 days and chambers were sampled at 8 time-points, 2, 9, 15, 27, 36, 46, 55, and 63 days after the start of the experiment. At each time-point, 10–20 individuals were selected from randomly chosen cobbles and carefully removed from the cobbles using a razor blade. Efforts were made to sample a representation of available sizes of adults (5–13 mm basal diameter). Basal diameter at the widest point, operculum length at longest point, and height at tallest point were measured for each individual (±0.1 mm). The developmental stage of the embryos was assessed under a dissecting microscope (50×) using the developmental scale described in Table 1 (J Pineda and VR Starczak, personal communication). Somatic and gonad tissue were dissected, dried at 55 °C for at least 48 h, and then weighed with a microbalance. At the final time-point (Day 63), a subsample of embryos (200–800) was taken from each individual and counted using a Sedgwick Rafting Counter, then dried and weighed to determine the average mass per embryo for each treatment.

Table 1: Description of developmental traits used to stage barnacle embryos (J Pineda and V Starczak, Woods Hole Oceanographic Institution, personal communication).

Stage	Description
0	White tissue.
1	Yellow tissue, gonad is stringy and not yet egg-shaped.
2	Eggs are visible and ovoid, but not developed.
3	Eggs are translucent and yellow. They have brown eyespots, but no body structure
4	Visible naupliar body structure, including caudal spines and distinctive eyespot, developing gut sometimes visible. Eggs beginning to change color from yellow to white.
4b	Fully-developed nauplii with appendages and two brown spots, embryos contained within egg case.
5	Free-swimming or loose nauplii with appendages free from the membrane.

Data Processing Description

Calculations and measurement precision are given in the Parameters section, below.

BCO-DMO Processing:

- added conventional header with dataset name, PI name, version date, reference information
- renamed parameters to BCO-DMO standard
- reformatted date from d-Mon-yy to yyyy-mm-dd

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Data Files

File	
barnacle_brood_E2_sort.csv	(Comma Separated Values (.csv), 50.25 KB) MD5:41720bfe350ad107e279a0ec25cfae70
Primary data file for dataset ID 636941	

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Related Publications

Barnes, H. (1963). Light, temperature and the breeding of Balanus balanoides. Journal of the Marine Biological Association of the United Kingdom, 43(03), 717. doi:10.1017/s0025315400025649 https://doi.org/10.1017/S0025315400025649
Methods

Crisp, D. J. (1959). The Rate of Development of Balanus balanoides (L.) Embryos in Vitro. The Journal of Animal Ecology, 28(1), 119. doi:10.2307/2018
Methods

Crisp, D. J., & Patel, B. (1969). Environmental control of the breeding of three boreo-arctic cirripedes. Marine Biology, 2(3), 283–295. doi:10.1007/bf00351151 https://doi.org/10.1007/BF00351151
Methods

Rognstad, R. L., & Hilbish, T. J. (2014). Temperature-induced variation in the survival of brooded embryos drives patterns of recruitment and abundance in Semibalanus balanoides. Journal of Experimental Marine Biology and Ecology, 461, 357–363. doi:10.1016/j.jembe.2014.09.012
General

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Parameters

Parameter	Description	Units
temp_air	Air temperature in environmental chamber (degrees Celsius +-0.5C)	degree Celsius
temp_water	Water temperature in environmental chamber (degrees Celsius +-0.5C)	degree Celsius
chamber	Code name of environmental chamber	unitless
date_local	local date	yyyy-mm-dd
individual	barnacle identification	unitless
filter_egg_initial	initial dry weight of filter (mg +-0.001 mg)	mg
filter_egg_final	dry weight of filter + eggmass (mg +-0.001 mg)	mg
egg_mass	dry weight of egg mass (mg +-0.001 mg) (= Filter final - initial)	mg
filter_somatic_initial	initial dry weight of filter (mg +-0.001 mg)	mg
filter_somatic_final	dry weight of filter + somatic tissue (mg +-0.001 mg)	mg
somatic_mass	dry weight of somatic tissue (mg +-0.001 mg) (= Filter final - initial)	mg
wgt_egg_somatic	ratio of egg weight to somatic weight (=Egg_mass/Somatic_mass)	unitless

basal_diam	basal diameter of shell (mm +-0.1 mm)	mm
operculum_len	operculum length (mm +-0.1 mm)	mm
shell_height	height of shell (mm +-0.1 mm)	mm
stage_0	number of embryos in Stage 0 (See Table 1 below for definitions)	unitless
stage_1	number of embryos in Stage 1	unitless
stage_2	number of embryos in Stage 2	unitless
stage_3	number of embryos in Stage 3	unitless
stage_4	number of embryos in Stage 4	unitless
stage_4b	number of embryos in Stage 4b	unitless
stage_5	number of embryos in Stage 5	unitless

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Deployments

Eurowinter2_US

Website	https://www.bco-dmo.org/deployment/637003
Platform	Univ_S_Carolina
Start Date	2012-12-08
End Date	2016-03-31
Description	Barnacle studies

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Project Information

Climate Change and Biogeography: Effects of Extreme Events (EUROWINTER2)

Website: http://tbone.biol.sc.edu/forecasting_test

Coverage: Atlantic coast of Europe from central Portugal to northern Scotland

The long term goal of this project is to make verifiable forecasts of the biodiversity consequences of climate

change in the coastal zone. By falsifying some and corroborating other biogeographic hypotheses, the investigators will establish a mechanistic framework for forecasting that can be verified by hindcasting the biogeographic changes that have been documented over the past century of climate change. The confluence of the rich biogeographic history of the European intertidal, the extreme conditions of the past 3 cold winters, and our rapidly expanding abilities in ecological forecasting provide a unique opportunity to make extraordinary progress in forecasting biodiversity responses to climate change. The investigators will quantify the metapopulation dynamics of ecologically dominant intertidal species to determine mechanisms responsible for setting geographic limits, and develop long term forecasts of future change. This research will also allow them to test the effect of episodic extreme events on the usefulness of ensemble methods for biogeographic forecasting. In a changing climate, with increasing frequencies of extreme events, it is important to determine whether the biogeography can ever "catch up", or whether the time lags caused by the demographic storage effect and connectivity will prevent the biology from ever tracking the long term change. The methods for ecological engineer and biodiversity forecasting and hindcasting that are described here have general applicability to marine habitats worldwide. All ecosystems have ecologically dominant species that control the rest of the assemblage of organisms, and they all are metapopulations whose connectivity and age structure determines their sensitivity to climate change and extreme events via the demographic storage effect. The players change from place to place and the oceanographic context also changes, but the methods applied here are broadly transferable.

Intellectual Merit: The results of this study will impact dramatically the discourse on the impacts of climate change. Results to date have centered on descriptions of gradual biogeographic range changes and exploration of the mechanisms driving those changes. Rarely in this literature is there discussion of the importance of broadscale episodic catastrophic events on biogeographic ranges, or how to capture those events in forecasting ecological response to climate change. A central prediction of climate change is an increase in the frequency of such potentially catastrophic climatic events which have the power to periodically reset the range boundaries of species in a ratchet-like manner. Of central interest is the degree to which such resets by extreme events determine long-term biogeographic patterns due to the combination of metapopulation dynamics and time lags caused by "storage effects" of long-lived individuals.

Broader Impacts: This project will produce an annotated bibliography of biogeographic data from the Portuguese, Spanish, and French biodiversity literature of the 19th and early 20th centuries, much of which is unavailable in North America. The project will develop a climate change atlas of the European coast including measures of historical risk and the distribution of extreme events. A forecast atlas of the next century will be developed by coupling population models to regional climate forecasts. These products will be used as models of ways to translate scientific results into products of greater utility. The PIs have used this approach in their web-based 7-day ecological forecasts of stress in marine communities, which are in the initial phase of transition to NOAA operational status. The PIs have also engaged policy makers and have worked closely with resource managers.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1129401
National Aeronautics & Space Administration (NASA)	NNX11AP77G

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